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OIL SPRAYS FOR DECIDUOUS FRUIT TREES
BY THE TANK-MIXTURE METHOD¹

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MUCH PROGRESS HAS BEEN MADE in the past ten years in the development of oil sprays suitable for spraying deciduous fruit trees in California. From crude-oil emulsions, mechanical mixtures, distillate emulsions, and miscible oil emulsions we have advanced to paste-type emulsions and the so-called "soluble" oil emulsions; and within recent years the use of the tank-mixture method has become an established practice in the orchards of northern California.

The fact is well established that an oil spray is superior to liquid lime-sulfur solutions in the control of San Jose scale (*Aspidiotus perniciosus* Comst.) and other scale insects, and also that it is very effective in destroying the egg masses of the fruit-tree leaf roller (*Archips argyrospila* Walk.) as well as the eggs of certain mites. The penetrating and spreading characteristics of the oil insure better results than can be obtained with the lime-sulfur wash. In addition to being more effective, oil sprays are easier to handle and apply, and cost less than lime-sulfur.

Along with this progress made in oil sprays there came new problems pertaining to the type of oil and the kind and amount of emulsifier required to give the most satisfactory results. Since improvement has been made in the type of oil used in the emulsions and in the oil-depositing quality of the spray, the chance of injury to dormant deciduous trees is small. The safety of the dormant oil sprays is largely dependent upon the sulfonation and viscosity of the oils. The only precautions now practiced in the use of dormant oil sprays are that the early applications are not made before the trees are dormant nor before enough rain has fallen in the early winter to wet the soil sufficiently; and that the late applications are not made after the "green tip" stage of the bud. In general, in northern California the dormant sprays are applied in the months of January and February.

¹ This circular presents in condensed form the information originally published in Bulletin 579, *The Tank-Mixture Method for Dormant Oil Spraying of Deciduous Fruit Trees in California*, and supersedes that publication. In addition it includes considerable new data not previously published.

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The fruit grower is often confused by the many brands of emulsions offered him and by the claims made by some salesmen. Too frequently the price alone may be the deciding factor. Seasonal changes in the formulas by the manufacturers, and a change of brands by the growers are often responsible for notable differences in efficiency. These, together with the ever present difficulty of obtaining sufficient coverage in making the application, may prevent satisfactory control.

QUALITIES OF SPRAY OILS

There are certain special terms used in describing spray oils which should be explained at this point.

Spray oils are one type of product obtained in the distillation and purification of crude oil. The crude oil is placed in stills and is heated, under partial vacuum, to successively higher temperatures. Spray oils are the less volatile fractions which come over after the lighter stove distillates and before the heavier lubricating oils.

The purification process is accomplished by removing the undesirable unsaturated and aromatic hydrocarbons, which are regarded as impurities, and treating the distillate first with liquid sulfur dioxide, later with strong sulfuric acid. The unsaturated and aromatic compounds are removed as a heavy dark sludge. The purified oil is neutralized by washing with an alkaline solution and is then thoroughly washed with water. It is later dried by blowing air through the oil.

The unsaturated and aromatic hydrocarbons are particularly injurious to trees, and therefore the safety of an oil depends on the extent to which these compounds are removed. The purity of a spray oil is determined by the percentage that remains unchanged when subjected to the sulfuric acid test, known as the sulfonation test. Dormant spray oils generally show an unsulfonatable residue of from 65 to 74 per cent. Foliage spray oils have an unsulfonatable residue of 90 per cent or more.

Spray oils have been classified as light, light-medium, medium, and heavy, on the basis of viscosity and distillation. The viscosity pertains to the flow of oil and is expressed as the number of seconds required for 60 cubic centimeters at a temperature of 100 degrees Fahrenheit to flow through a small orifice in an instrument known as the Saybolt Universal viscosimeter.

The distillation range gives the minimum and maximum temperatures between which the distillation takes place and the percentage of oil distilling over at certain temperatures within the range. The distillation range is an index of volatility and is considered more reliable than viscosity in determining the heaviness of spray oils.

A "straight-cut" oil is one derived from distillation within a definite range of temperature and is not a blended oil.

A blended oil is one derived by mixing oil of a lower viscosity and distillation range with an oil of a higher viscosity and distillation range.

The viscosity of such a blended oil is not particularly indicative of the insecticidal property of such an oil. The distillation range affords a more reliable measure of insecticidal value.

COMMERCIAL OIL EMULSIONS

In northern California at present, nearly a score of commercial oil emulsions are offered for use in deciduous-fruit sprays. Many of these are excellent emulsions made from refined, light lubricating oils and different types of emulsifiers. The greatest difficulty lies in the wide variance in the oil-depositing properties of the different emulsions. In general there are two types of emulsions: the "quick-breaking" emulsion and the "tight" emulsion. In the former type a minimum amount of emulsifier is used and the oil globules are less securely held in the dilute spray so as to produce a heavier oil deposit when the spray strikes the bark or foliage of a tree. This type is more desirable and efficient than the more stable emulsions called tight emulsions, in which the oil droplets are more securely held by the emulsifier and deposit comparatively thin films of oil.

The oil-depositing, wetting, and spreading properties of any spray are of much importance. A spray may overcome the resistance of the bark or foliage to wetting and yet deposit but comparatively little oil. Much of the oil may be lost in the runoff, or drip, from the tree. On the other hand, a definite amount of wetting and spreading is essential to give a quick, even distribution of the oil deposited.

The oil-depositing quality of the spray bears an important relation to the dosage of oil that is required to give effective control. This quality is determined by the kind and amount of emulsifier contained in the emulsion or the spray mixture in the tank. Manufacturers of emulsions have apparently not given this important point adequate consideration.

A paste-type spray oil emulsion usually consists of from 80 to 85 per cent spray oil, which has been agitated into a stiff paste by the addition of emulsifier and water. The common emulsifiers used are ammonia caseinate, and various types of soap compounds. The use of such emulsifiers usually insures the stability of the emulsion and the suspension of the oil particles when diluted in water. In general, dormant paste-type emulsions are usually tight emulsions.

A so-called "soluble" oil emulsion consists of from 94 to 96 per cent spray oil, the remainder being emulsifier. In this very fluid emulsion the emulsifier is dissolved in the spray oil and readily mixes with water. Various oil-soluble soaps are employed as emulsifiers in this type of emulsion. In general this emulsion is of the quick-breaking type though some are comparatively tight emulsions.

The results of laboratory tests on the amount of oil deposited on 25 square inches of waxed surface by 14 brands of commercial oil emulsions are shown in table 1. In each test the spray was a 3 per cent emulsion.

Each test was repeated ten times in order to obtain an average which may be regarded as reasonably correct. The exposure to the spray was for 15 seconds.

In table 1 the wide variation in the oil-depositing properties of the commercial oil emulsions is shown. Foliage-spray emulsion No. 11, which shows the lowest amount of oil deposit, is sold for the same purposes and has been recommended to be used at the same dosage as emulsion No. 8, which shows the highest deposit. A manufacturer may sell three or more brands of emulsions to be used at the same dosage, and yet the emulsions may differ widely in oil deposit.

TABLE 1
AMOUNT OF OIL DEPOSITED BY COMMERCIAL OIL EMULSIONS ON
25 SQUARE INCHES OF WAXED SURFACE

Dormant-spray emulsions		Foliage-spray emulsions	
Brand No.	Oil deposit in milligrams	Brand No.	Oil deposit in milligrams
1.....	22	8.....	28.0
2.....	24	9.....	18.0
3.....	19	10.....	8.7
4.....	22	11.....	4.0
5.....	17	12.....	7.0
6.....	33	13.....	20.4
7.....	34	14.....	5.6

The changing of the type or the amount of emulsifier used in the manufacture of emulsions naturally changes the properties of the emulsion. These changes may sometimes occur during a season, and the user of the material may not be aware of the difference in the product.

At the request of deciduous-fruit growers in northern California, the investigation of spray oil emulsions was begun in 1930 by the University of California to determine what type of emulsion gives the highest efficiency, and why more uniform results are not obtained in the orchard.

The success of the tank-mixture method in spraying citrus trees in southern California was very marked, and its application to deciduous fruit trees in northern California remained a comparatively new field. An earlier attempt in Santa Clara County to use a certain oil and calcium caseinate spreader started a few growers to using these materials; but since no provision was made for proper agitation, the results were unsatisfactory. The economic situation in the fruit industries also made it necessary to lower the costs of insect control. A solution to both problems, that of obtaining a higher uniform efficiency, and saving on cost of materials, was offered by the tank-mixture method. After three years of field experiments (1930-33) with the standard spray equipment (fig. 1) in the deciduous fruit orchards of northern California, this method was presented to the growers and has proved efficient and economical.

In the development of the method an available supply of the proper type of oil and spreader was required and, most difficult of all, the agitation necessary to give a uniform mixture in the spray tank had to be developed. Through the coöperation of four major oil refineries, a supply of oil was made available. Careful laboratory and field tests soon showed that the blood-albumin spreader used in southern California was the best spreader.

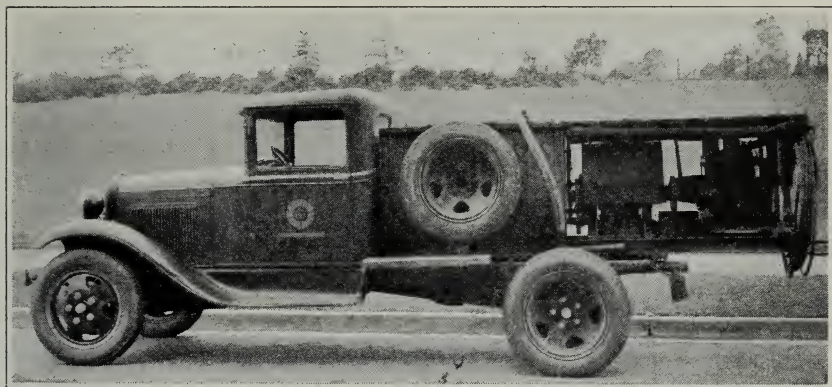


Fig. 1.—The Experiment Station spray equipment used in the experiments.
(From Bul. 579.)

The matter of procuring adequate agitation in the comparatively low-powered spray equipment of deciduous orchards was a problem. The high speed (200 r.p.m.) agitation, as recommended in the citrus orchards, was excellent for equipment with 8-hp. motors or above; but to add this $\frac{1}{2}$ -hp. requirement for agitation to the outfits using 3- or 4-hp. motors and yet maintain a satisfactory pressure at the pump was almost impossible. The solution of this problem was found in changing the type of agitators in the spray tank, as is shown in the section "Spray-Tank Agitation."

THE TANK-MIXTURE METHOD

The following procedure shows the difference in the use of commercial oil emulsions and the tank-mixture method: Instead of buying the emulsion in the paste form in steel drums and adding it in proper proportions to the water in the spray tank, the grower buys the spreader and spray oil and adds them separately to the water in the spray tank, and a uniform mixture is produced and maintained by the agitators.

The usual method employed is to fill the tank with water up to, or above, the agitator shaft, start the motor and agitator, sift in the spreader, and add the oil as the tank is filling with water. Proper agitation is essential and no sprayer should be used until the requirements given under "Spray-Tank Agitation" have been met.

The advantages of the tank-mixture method are that it is possible to obtain materials of definite known quality, purchased upon specification, free from blends, and at a saving of approximately 50 per cent in cost. The oil-depositing property of tank-mixed spray is higher than that of the commercial oil emulsions and, therefore, a lower dosage may be used. The ease and accuracy in measuring and handling the materials appeals to most growers, and the spreading and wetting properties of the spray are equal or superior to those of commercial oil emulsions at the same concentrations.

A comparison of the costs for dormant spraying for the season of 1936–37, as recommended for San Jose scale control, is shown below :

Commercial oil emulsion :

5 gallons emulsion per 100 gallons dilute spray at \$0.18.....\$0.900

Tank-mixture method:

3 gallons oil per 100 gallons dilute spray at \$0.115.....\$0.345

4 ounces spreader per 100 gallons dilute spray..... 0.055..... 0.400

Saving per 100 gallons dilute spray.....\$0.500

Another important factor is that the tank-mixture spray is compatible in combination with bordeaux mixture, or lime-sulfur, or caustic soda, which is not true of all emulsions. This makes possible a combination spray which may serve a dual purpose. Tank-mixed spray is apparently not affected by the hardness of spray water.

DORMANT SPRAY OILS EMPLOYED

In the orchard experiments conducted in 1930–33 with the tank-mixture method, three types of nonblended (straight-cut) dormant oils were employed to determine comparative values for scale kill and possible injury to fruit buds. These oils were :

Grade	Unsulphonatable residue	Viscosity Saybolt at 100° Fahrenheit
Brown Neutral.....	55–65	100–110 seconds
Tank-Mix Grade B.....	65–70	100–120 seconds
Tank-Mix Grade A.....	70–75	100–120 seconds

Blends of other oils were made to give viscosities of 70, 120, 140, 160, and 200 seconds Saybolt at 100° Fahrenheit.

No injury to the fruit buds of apple, pear, or prune was noted from the application of any of the oils used except on prune, where the two higher viscosity blends (160–200 seconds) when applied late delayed the blossoming time fully one week.

No appreciable difference was noted in the control of San Jose scale or brown apricot scale (*Lecanium corni* Bouché) in any of the applications with the oils of from 100 to 120 seconds viscosity.

The results thus obtained permit recommending the Tank-Mix Grade A oil of 70 per cent or above in unsulfonatable residue and with a viscosity of from 100 to 120 seconds Saybolt 100° Fahrenheit for all dormant tank-mixture work. Spray oils of these specifications are available from the following oil companies:

Associated Oil Co.	Avon 100 Spray Oil
Shell Oil Co.	Dormant Spray Oil No. 11
Standard Oil Co.	Calol Dormant Spray Oil
Union Oil Co.	Dormant Spray Oil 3-110-70

SUMMER OR FOLIAGE SPRAY OILS

In the control of mites (*Tetranychus telarius* Linn., *Paratetranychus pilosus* C. & F., and *Bryobia praeiosa* Koch) during the foliage period, the application of a summer-oil emulsion is often recommended. For this purpose a more highly refined oil is employed and a lower viscosity is necessary. Spray oil is also often added to form a combination spray at this period in the control of codling moth (*Carpocapsa pomonella* Linn.) where lead arsenate is used or with nicotine sulfate in the control of thrips, leafhopper nymphs, and immature mealybugs.

As a summer spray on most deciduous fruit trees an oil having a viscosity of from 60 to 70 seconds and an unsulfonatable residue of 90 per cent or above is recommended. This is what is known as a light-medium grade of oil and may be obtained from the major oil companies under the following classifications:

Associated Oil Co.	Avon 70 Spray Neutral 90
Shell Oil Co.	Shell Tank-Mix No. 2 Light-medium 90
Standard Oil Co.	Calol Spray Oil Grade No. 2 Light-medium 90
Union Oil Co.	Union Spray. Oil 1-65-90

A few varieties of apples have been found which will show injury about the calyx end when oils of higher viscosity are applied, and on such varieties as Yellow Newtown, Smith Cider, and Rhode Island Greening, a light oil (Grade 1) of not over 60 seconds viscosity should be employed.

SPREADER FOR THE TANK-MIXTURE SPRAY

In the earlier attempts at emulsifying dormant oils a calcium caseinate spreader was used. With proper agitation the emulsification and spread are fairly satisfactory, but when hard water is encountered, emulsification becomes impossible. In many places in northern California where hard water occurs, the calcium caseinate spreader cannot be safely recommended. This spreader has also been found to have a tendency to build up too heavy an oil film in the case of heavy spray applications and this makes its use dangerous under some conditions on such crops as apricot and peach.

Many types of spreaders have been studied for spreading and oil-depositing properties in the laboratory, but none have as yet been found to equal the powdered blood albumin. This spreader is composed of 1 part Grade A powdered blood albumin of a definitely high solubility and 3 parts of a suitable finely ground diatomaceous earth. The spreader is used at the rate of 4 ounces to 100 gallons of spray. It has been obtained in glassine-lined bags in two convenient sizes from manufacturers in Oakland and San Francisco. The 8-ounce package, sufficient

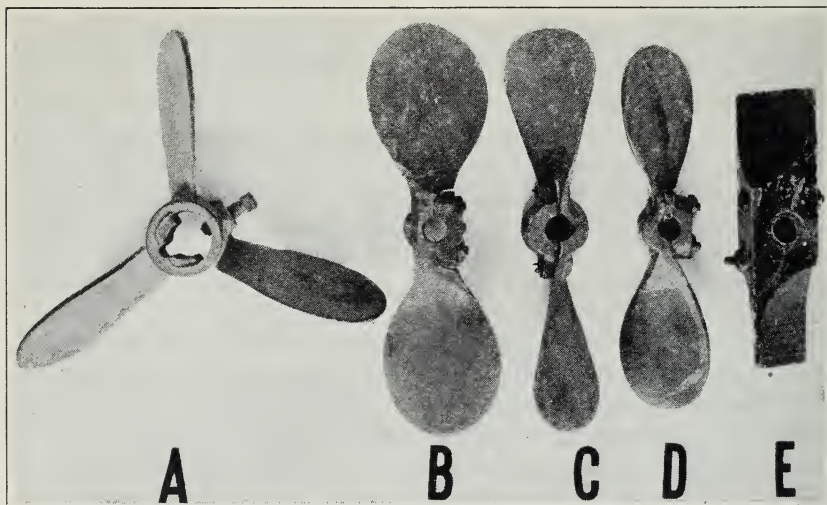


Fig. 2.—Various propeller types of agitators used in spray tanks in northern California. Agitators *C*, *D*, and *E* are not satisfactory with oil sprays. (From Bul. 579.)

for a 200-gallon tank, is sold at 11 cents a package; and the 12-ounce package, sufficient for a 300-gallon tank, at 16 cents. It is inadvisable for anyone but a properly equipped manufacturer to prepare this spreader.

SPRAY-TANK AGITATION

Effective agitation is a requisite of primary importance in the use of most sprays. In using even the most stable commercial oil emulsions conditions are sometimes encountered where, owing to the breaking of the emulsion in hard water, or to the interruption of the spraying before the tank is emptied, the oil may become concentrated at the surface of the water. Also in the use of insoluble insecticides, such as powdered lead arsenate and sulfur, sufficient agitation is important in order that a uniform concentration may be obtained. The agitation requirement prescribed for tank-mixed spray assures that a uniform mixture will be had under all conditions.

In testing something over 200 sprayers in the field it was found that very few had adequate agitation, owing largely to the comparatively

slow speed of the agitator shaft and to the propeller type of agitators (fig. 2). In Bulletin 527,³ it has been shown that a uniform mixture may be obtained by increasing the speed of the shaft to 200 r.p.m. and using the proper kind and number of propeller-type agitators. The energy consumption is approximately $\frac{1}{2}$ hp. This high-speed agitation is prac-

TABLE 2
RESULTS OF AGITATOR TESTS, USING ONLY OIL AND WATER

Make	Spray-tank capacity, in gallons	Depth, in inches	Length, in inches	Agitators				Number of gallons in tank when samples were taken			
				Number	Type*	Size	Speed, in r.p.m.	300	200	100	10
								Per cent of oil in sample			
Propeller-type agitators											
Bean	200	28	52	2	A	large	98	...	0.3	0.9	1.8
Hardie	200	33	44	2	B	large	150	...	0.0	0.1	1.9
Bean	300	33	64	3	A	large	90	0.1	0.1	1.0	1.8
New flat, square-end agitators											
Bean	200	28	52	4	Flat	4-inch	90	...	1.0	1.0	1.0
Hardie	200	33	44	4	Flat	4-inch	99	...	1.0	1.0	1.0
Bean	300	33	64	4	Flat	8-inch	96	0.9	1.0	1.0	1.1
Combinations of new flat agitators and propeller types											
Hardie	200	33	44	{ 2 2	{ A Flat	{ large 4-inch	{ 100	...	1.0	1.0	1.0
Hardie	200	33	44	{ 2 2	{ B Flat	{ large 4-inch	{ 96	...	0.7	1.0	1.2
Hardie	200	33	44	{ 2 2	{ B Flat	{ large 4-inch	{ 110	...	1.0	1.0	1.0

* Type letters "A" and "B" refer to the propeller-type agitators shown in figure 2.

ticable with sprayers having 8-hp. motors, or over, and can be obtained by simply changing the ratio of the gears between the pump and the agitator shaft.

In northern California a large percentage of the sprayers are equipped with tanks of 100-, 200-, or 300-gallon capacity, and with motors of 2½, 3, 4, 6, and 8 hp. A few sprayers have 300- and 400-gallon tanks and 12- or 15-hp. motors. The normal speed of the agitator shaft on the different makes of equipment varies widely. It is important to know this speed

³ Smith, Ralph H. The tank-mixture method of using oil spray. California Agr. Exp. Sta. Bul. 527:1-84. Reprinted 1933.

before making any changes in the agitators. This may be readily determined by simply counting the revolutions of the sprocket at the end of the shaft outside the tank.

Investigations made in the orchards and in the laboratory of the Division of Agricultural Engineering at Davis have shown that adequate agitation cannot be obtained with the use of the propeller-type agitators (table 2) at speeds of from 100 to 120 r.p.m., and it is impracticable to employ the high-speed agitation on the low-powered sprayers. Accord-

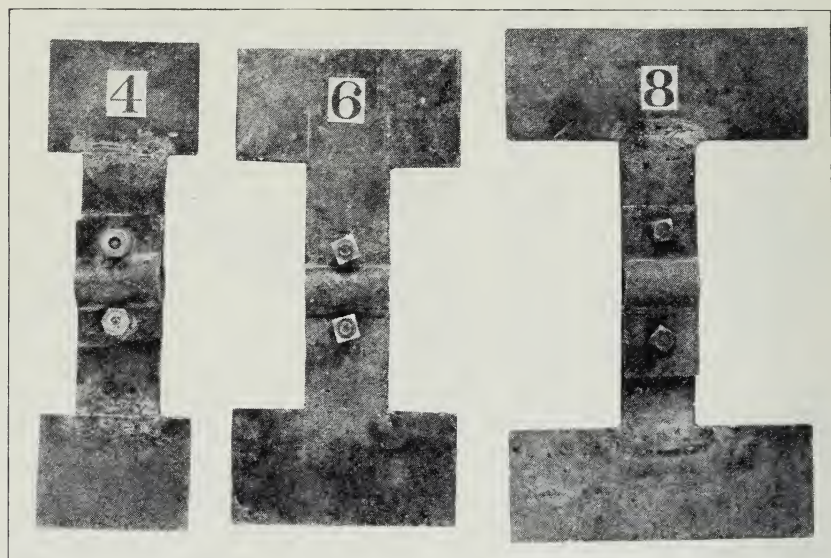


Fig. 3.—The new, flat, square-end agitators which should replace the propeller types in all spray tanks. (From Bul. 579.)

ingly, a new-type, flat, square-end agitator (fig. 3) has been developed, which, in 100-, 200-, and 300-gallon tanks, will give uniform mixtures with an energy consumption of less than $\frac{1}{5}$ hp.

This new agitator is made of $\frac{3}{16}$ -inch mild steel from 2-inch and 3-inch band material. The tips may be either welded or riveted on. The 13-inch length (fig. 4) is for tanks having the agitator shaft about 7 inches above the bottom of the tank and is to be run at speeds of from 95 to 110 r.p.m. Similarly patterned agitators 10 inches in length may be employed in tanks having the agitator shaft about $5\frac{1}{2}$ inches above the bottom of the tank, at speeds of 140 to 150 r.p.m. At a speed of 100 r.p.m., four of the agitators 13 inches in length require approximately the same amount of energy as four of the 10-inch agitators turning at a speed of 140 r.p.m.

The first three tests presented in table 2 are with propeller-type agitators, and show lack of uniformity in the mixture. The next three tests with the new, flat, square-end agitators show uniform mixtures. The last

three tests, in which two of the new, flat, square-end agitators are used in combination with two propeller-type agitators, show that a speed of 100 to 110 r.p.m. is required. In all tests the tank was filled with water, and dyed kerosene was poured on the surface. The agitators were then started, and after running for 1 minute, the spray nozzles were opened and samples were taken at intervals during the emptying of the tank.

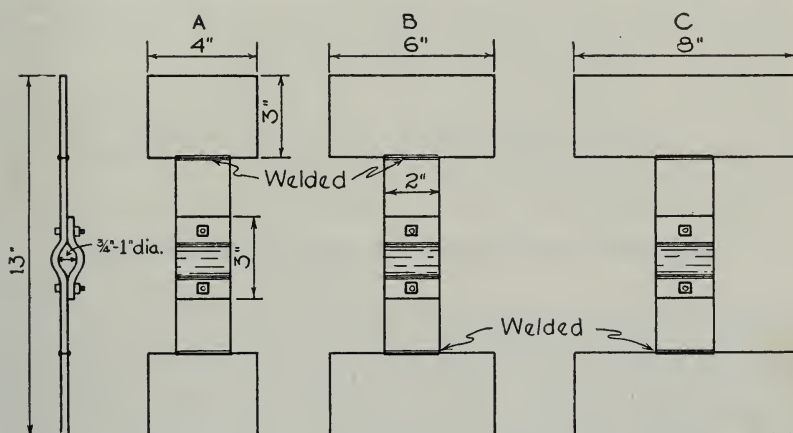


Fig. 4.—Patterns for the new, flat, square-end agitators that are recommended.
(From Bul. 579.)

Since the dimensions of spray tanks are not uniform, caution should be used in securing sufficient agitation. Tanks differ particularly in their length and depth. It is advised that a test be made after the suggested number of agitators have been installed.⁴

In tanks having the agitator shaft 7 inches above the bottom and of 100- and 200-gallon capacity, with a speed on the agitator shaft of 95 to 110 r.p.m., four of the 13-inch agitators with 4-inch tips are recommended. In tanks of 300-gallon capacity, with the speed of the agitator shaft of 95–110 r.p.m., four of the 13-inch agitators with 8-inch tips are recommended. In 400-gallon capacity tanks, which usually have more than 8-hp. motors, it is better to resort to a higher speed on the agitator shaft, though four of the 8-inch tip agitators with a speed of 120 r.p.m., or above, are adequate.

In tanks having the agitator shaft about 5½ inches above the bottom, and of 100- and 200-gallon capacity, with a speed on the agitator shaft of 140–150 r.p.m., four of the 10-inch agitators with 4-inch tips are required. In tanks of 300-gallon capacity four of the 8-inch tip agitators at the same speed are sufficient.

⁴ With the newer types of spray equipment having tanks of various shapes and sizes it is recommended that the grower seek information from the Division of Agricultural Engineering, Branch of the College of Agriculture, Davis, California, as to the requirements for adequate agitation.

Two of the agitators should be placed as near the ends of the tank as possible and the other two spaced evenly between the end agitators. They may be set at right angles to each other or all four parallel.

It has also been found possible to combine the new flat agitators with certain of the larger propeller-type 3-bladed (fig. 2, *A*) and 2-bladed (fig. 2, *B*) agitators and obtain satisfactory results, as is shown in table 2. Two 3-bladed (fig. 2, *A*) agitators or two large 2-bladed (fig. 2, *B*) agitators and the two 13-inch new flat agitators with 4-inch tips at 110 r.p.m. gave a uniform mixture in 200-gallon tanks.

In certain underslung tanks which have the agitator shaft set at an angle the blade-type agitators present are usually adequate if running at a sufficient speed (140 r.p.m.). If not, however, a flat agitator can be designed to fit the different depths in the tank.

ORCHARD EXPERIMENTS IN THE SEASON OF 1931-32

During the winter spray season of 1931-32 over 4,000 gallons of dilute tank-mixed sprays were applied on several varieties of apples, Bartlett pears, and prunes on experimental plots in the control of San Jose scale and brown apricot scale. Spray oils of viscosities of 100, 120, 140, 160, and 200 seconds were employed at dosages of 3, 4, and 5 gallons per 100 gallons of dilute spray. The amount of spreader was varied from no spreader to 4, 6, 8, and 10 ounces per 100 gallons. As a comparative check some of the standard commercial oil emulsions were used at recommended dosages on each orchard sprayed. Counts of the San Jose scale were made at harvest time on 1,000 to 3,000 apples per plot. Counts were made of brown apricot scale six weeks after the applications. The data obtained indicate that the most effective control of the San Jose scale was obtained with the oils of 100 and 120 seconds viscosity and with 4 ounces of blood albumin spreader. Where no spreader was used the coverage was unsatisfactory. No difference was noted in the blooming time of the apples or pears on any of the spray plots where oils of different viscosities had been used.

In the control of brown apricot scale on prune, the best results were obtained with the four ounces of spreader and with oils of 100 and 120 seconds viscosity. With late applications, the oils of 140 seconds viscosity and above delayed the bloom of prunes fully 10 to 14 days. January sprays are preferable to sprays applied late in February.

ORCHARD EXPERIMENTS IN THE SEASON OF 1932-33

During the spray season, 1932-33 over 7,500 gallons of dilute spray were applied experimentally on apricots, prunes, apples, and pears. Dosages for San Jose scale, brown apricot scale, fruit tree leaf roller eggs, and brown mite eggs were determined. Combination sprays of bordeaux mixture and the tank-mixture spray were applied to apricots

in the "pink bud" stage, for control of brown rot and fruit tree leaf roller. The stimulating effect of different oils applied at monthly intervals on prunes was studied. The experiments were conducted in ten widely separated orchards of the coastal area, and in each orchard one or more standard commercial oil emulsions were used for comparison. Oils of three grades and viscosities of from 70 to 140 seconds were used.

Scale counts were made about eight weeks after the applications, by counting all scale on 5 twigs—12 to 15 inches long—taken from each of 20 trees in each spray plot.

RESULTS OF 1932-33 ORCHARD EXPERIMENTS

In the control of San Jose scale it has been well demonstrated that where the bark is not rough and the scale not encrusted a dosage of 3 gallons of Tank-Mix Grade A oil and 4 ounces of blood albumin spreader per 100 gallons of dilute spray is sufficient.

The brown apricot scale on prunes is comparatively easy to kill until it begins to develop wax. In the early season, this scale on prunes usually can be killed with a comparatively low dosage, while late in February it becomes more difficult. On apricot, growth is usually faster than on prune, and a higher dosage is required. Where bordeaux mixture is combined with oil sprays on apricots and used as late as the "pink bud" stage, the scale is not only more difficult to kill, but the effectiveness of the oil is reduced, and the oil dosage must be increased.

The standard recommendation for the spraying of fruit tree leaf roller eggs has been 7 gallons of commercial oil emulsion per 100 gallons of dilute spray. Experiments in 1932-33 have amply shown that on prune and apricot satisfactory control can be obtained by the tank-mixture method with a dosage of 4 gallons of Grade A oil and 4 ounces of blood albumin spreader per 100 gallons of dilute spray. The practicability of combining bordeaux mixture with the oil emulsion to be applied in the "pink bud" stage on apricots has been demonstrated.

THE TANK-MIXTURE METHOD AND STATIONARY SPRAY EQUIPMENT

Advisability of using a quick-breaking spray such as is produced by the tank-mixture method in the pipe lines of a stationary spray outfit was determined in field tests in 1935. Samples of spray taken at the end of 1,870-foot lengths of pipe, even after the flow had been stopped and started again, showed uniform percentages of oil when the flow in the pipe lines was more than 2 feet per second. Thorough agitation in the mixing tanks is as essential in this type of equipment as in ground equipment. Several stationary spray outfits in this state have successfully used the tank-mixture method for the past three seasons.

DOSAGE RECOMMENDATIONS FOR DORMANT OIL SPRAYS

San Jose Scale.—In infestations where the bark is relatively smooth and the scale not incrustated, 3 gallons of Tank-Mix Grade A oil and 4 ounces of powdered blood albumin spreader per 100 gallons of dilute spray is sufficient. The addition of $1\frac{1}{2}$ or 2 pounds of caustic soda per 100 gallons of dilute spray may be made where the moss condition on the trees to be sprayed warrants its use.

Brown Apricot Scale.—A dosage of 2 gallons of Tank-Mix Grade A oil plus 4 ounces of powdered blood albumin spreader per 100 gallons of dilute spray on prunes is recommended early in the season where the scale is not particularly advanced in development. Later in the season a 3-gallon dosage may be necessary. On apricots the scale usually develops faster and a 3-gallon dosage per 100 gallons is recommended. Where bordeaux mixture is used in combination with the oil spray, a dosage of not less than 4 gallons of oil per 100 gallons of dilute spray should be used on apricots.

Fruit Tree Leaf Roller Egg Masses.—A dosage of 4 gallons of the Tank-Mix Grade A oil per 100 gallons of dilute spray is recommended for the fruit tree leaf roller egg masses in the full dormant period. Where bordeaux mixture is to be combined in this spray the dosage should be 5 gallons of oil per 100 gallons of dilute spray.

Mite Eggs.—Eggs of mites are usually destroyed in any spray program for control of scale.

Mealybugs.—Overwintering infestations of mealybugs on pears and apples may be controlled with a combination spray of 4 gallons of Tank-Mix Grade A oil per 100 gallons of dilute spray and 3 gallons of liquid lime-sulfur solution per 100 gallons of dilute spray during the full dormant spray period. Add the lime-sulfur solution to the oil spray when the tank is two-thirds filled.

Italian Pear Scale.—This scale may be controlled with 5 gallons Tank-Mix Grade A oil per 100 gallons of dilute spray. If moss is present, $1\frac{1}{2}$ to 2 pounds of caustic soda per 100 gallons of spray may be added.

Oyster Shell Scale.—The control of this scale is more difficult and a combination spray of 4 gallons of Tank-Mix Grade A oil plus 5 gallons liquid lime-sulfur solution per 100 gallons of dilute spray should be used.

DOSAGE RECOMMENDATIONS FOR SUMMER-OIL SPRAYS

Mealybugs.—Immature forms of mealybugs may be controlled in the early summer with $1\frac{1}{2}$ gallons summer-type Tank-Mix oil plus 1 pint nicotine sulfate per 100 gallons of dilute spray.

Mites.—Immature and mature forms of the European red mite, almond mite, and two-spotted mite on foliage or fruit may be controlled

with $1\frac{1}{2}$ gallons summer-type Tank-Mix oil per 100 gallons of dilute spray.

Leafhoppers.—Nymphs of leafhoppers on foliage of apple or pear may be controlled by adding 1 gallon summer-type Tank-Mix oil and $\frac{3}{4}$ pint nicotine sulfate to codling moth lead arsenate sprays when the nymphs appear.

Codling Moth.—The eggs of the codling moth are destroyed by the addition of $\frac{3}{4}$ gallon summer-type Tank-Mix oil to lead arsenate sprays if applied within 10 days after a heavy flight of moths as indicated by bait-trap records.

